2. LM AND TEM INVESTIGATIONS ON THE UPPER CRETACEOUS AJKAITE OF HUNGARY III.

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Abstract

Light and transmission electron-microscope investigations were implemented on some trilete spores characteristic of the amber layers of the Ajka Brown Coal Basin. The presumed functions of the appendices of the *Appendicisporites tricuspidatus* spore type, with it's restricted regional and stratigraphic occurrences, are discussed in comparison with the elater bearing fossil and extant spores of the genus *Equisetum*. The results of the TEM Ajkaite trilete spore studies are compared with those LM data of the "adriennis" type spore massula.

Key words: Upper Cretaceous, Ajkaite, spores, LM, TEM.

Introduction

The Upper Cretaceous Carpathian Basin spore assemblages have several local or regional restricted elements (KEDVES and DINIZ,1983). Some of these data have been previously published (KEDVES, SZÓNOKY, MADARÁSZ and KOVÁCS, 2000), in particular the Eunormapolles type *Hungaropollis* GÓCZÁN 1964a; and the Schizaeaceous fern spore with long appendices, described by WEYLAND and GREIFELD (1953). The presumed function of the appendices of this type of spore and its stratigraphical and geographical distributions are the subject of this LM study. In addition, the ultrathin sections from the amber have produced the first results concerning the fossil sporoderm.

The aim of this paper is the following:

1. Investigate the spores of "tricuspidatus type" as one of a more or less local element of the European Normapolles Province, together with other local elements, that are found in the Carpathian Basin.

2. Present new ultrastructure TEM data from fossil Schizaeaceae spore type recovered from the Ajkaite.

Materials and Methods

Material from previously published LM studies (KEDVES, BORBOLA and PRISKIN, 2001; KEDVES and ALVAREZ RAMIS, 2002) were used in this investigation. The Ajkaite (sample KG-99) was embedded in Araldite (Durcupan, Fluka). The TEM photographs were taken with the Hungarian Academy of Sciences Department of Biophysics, Biological Research Center's Tesla BS-540 at a resolution of 6-7Å.

Results

LM Results: Nomenclatural question of *Appendicisporites tricuspidatus* WEYLAND and GREIFELD 1953 (Plate 2.1., figs. 1-4)

After the publication of THIERGART (1949) and WEYLAND and GREIFELD (1953) a large number of Lower and Upper Cretaceous spores were assigned to the form-genus *Appendicisporites.* These spores also included a large number that had thickened appendices. Many of these types of spores were placed in the form-genus *Plicatella* MALYAVKINA adding to the nomenclatural confusion. DEÁK (1963, 1965), tried to resolve this taxonomic problem. However, the nomenclature of the fossil Schizaeaceous spores has still not been satisfactorily resolved. For example, DAVIES (1985) in his monograph of the Anemiacean, Schizaeacean and related spores introduced the following taxa: *Plicatella tricuspidata* (WEYLAND and GREIFELD 1953, p. 12, Table 3, fig. 18) comb. nov. Early Senonian: formerly *Appendicisporites, Anemia.* GRANZOW and HELMERICH (1992, p. 439) wrote the following: "1949 wurd von THIERGART "*Sporites appendicifer*" und 1953 von WEYLAND and GREIFELD "*Appendicisporites tricuspidatus*" veröffentlich. Ein gegenüberstellung der beiden Sporen aus dem Senon von Deutschland bzw. Polen ergibt, dass sie eindeutung zur gleichen Formart gehören". These spores were classified as *Plicatella appendicifera.* This present study was restricted to only those spores in which the lengh of the appendices is longer than the spore radius. In regards to the current nomenclatural problems, it is agreed in this paper to accept the concept of WEYLAND and GREIFELD (1953, p. 43) citing the following: "THIERGART bezeichnet die Spore als eine stark spezialisierte kurzlebige Form".

The most important occurrences of the spores of "tricuspidatus type" are as follows:

Alb-Cenomanian. - *A. tricuspidatus* WEYL. and GR., Vojvodina and near Belgrade, Yugoslavia, PANTIC and DULIC (1994).

Cenomanian. - *A. tricuspidatus* WEYL. et GREIF., Pont Bati, Vendée, France, DURAND, TERS and VERGER (1963), *Appendicisporites tricuspidatus* WEYL. et GREIF. 1953, Charente-Maritime, France, DEÁK and COMBAZ (1967), *Anemia tricuspidata* (WEYLAND et KRIEGER) BOLKHOVITINA 1961, Laudun Gard, France, MÉDUS et TRIAT (1969), *A. tricuspidatus* WEYL et GREIF., Peruc Formation, Czech Rep., PACLTOVÁ and SVOBODOVÁ (1992), *A. tricuspidatus* WEYL. et GREIF., Blansko Graben, Czech Rep., SVOBODOVÁ (1997), *Appendicisporites tricuspidatus*, Poganovo Paralic Series Southeast Serbia, PANTIC and DULIC (1999).

Cenomanian/Turonian. - *A. tricuspidatus* WEYLAND et GREIFELD, León, Northern Spain, VAN AMEROM (1965), *A. tricuspidatus* WEYL. et GREIF. Vocontian Basin, Czech Rep., SVOBODOVÁ, MÉON and PACLTOVÁ (1998).

Turonian. - *A. tricuspidatus* WEYL. et GREIF. Sabran, Gard, France, DUCREUX, GAILLARD and SAMUEL (1982).

Plate 2.1.

1-4. *Appendicisporites tricuspidatus* WEYLAND et GREIFELD 1953., slide: KG-99-9, Cross-table number: 22.7/141.2, figs. 1,2. 500x, figs. 3,4, 1.000x.

5. Schizaeaceae spore of "adriennis type"., slide: KG-99-19, Cross-table number: 20.3/140.8.

6. Ultrastructure of a laevigate trilete spore in the amber. Block No.: 99-KG-5, Negative No.: 8103, 5.000x.

7. Detail of the ultrastructure of a massula of laevigate trilete spores. Block No.: 99-KG-5, Negative No.: 8106, 15.000x.

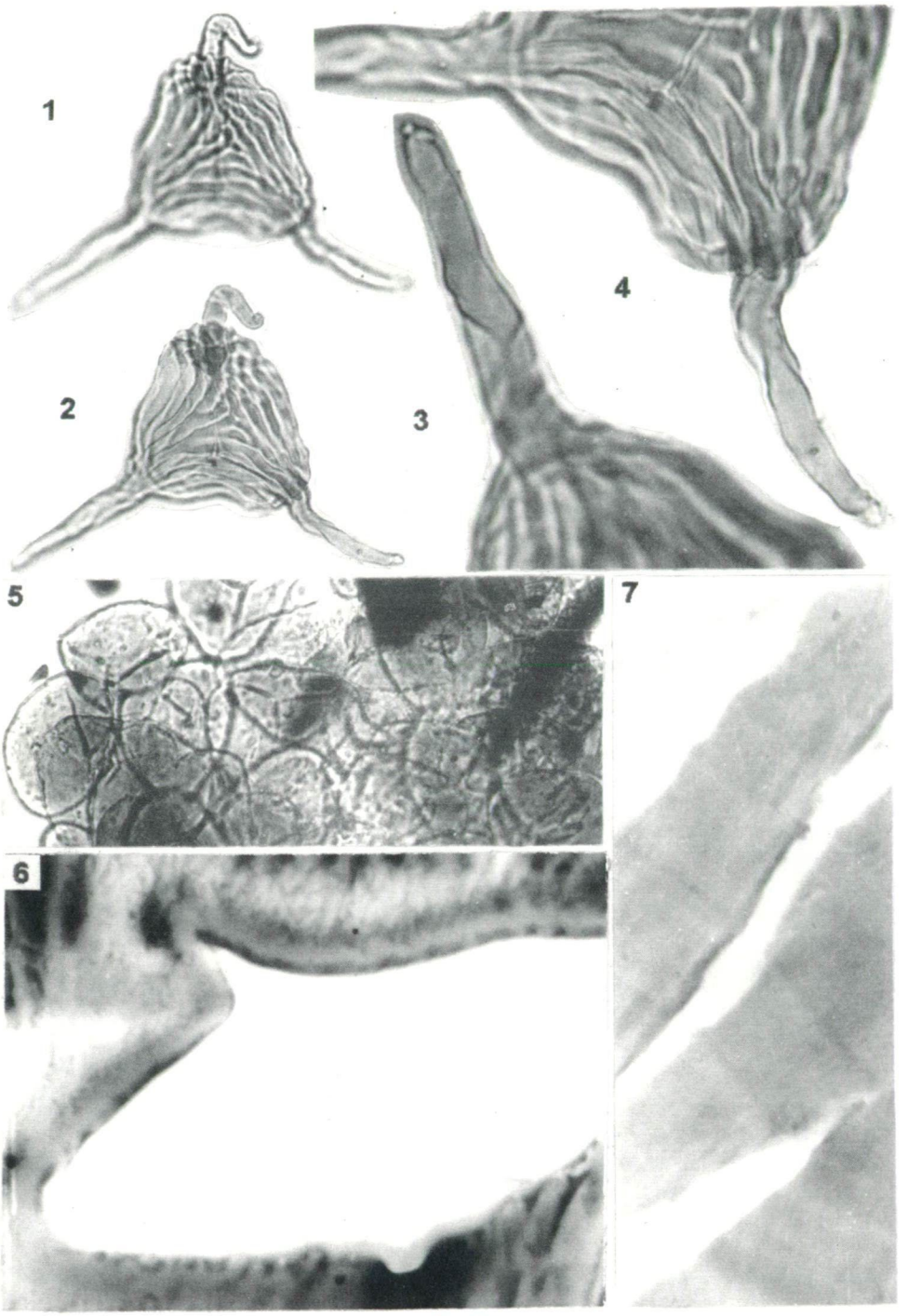

Plate 2.1.

Senonian. - *A. tricuspidatus* WEYL. et GREIF. Quedlinburg Germany, WEYLAND and GREIFELD (1953).

Santonian. - *A. tricuspidatus* WEYL. et GREIF. 1953, Ajka, Hungary, GÓCZÁN (1964a).

Santonian/Campanian. - *A. tricuspidatus* WEYLAND et GREIFELD (15), Bakony, Hungary, GÓCZÁN (1964a,b).

As regards the spores from the brown coal of Ajka we cite from the paper of GÓCZÁN (1964a); p. 233: "3. In zone "C" the spores with verrucate structure (13), *Appendicisporites tricuspidatus* WEYLAND et GREIFELD (15), 40-45 μ sized *Oculopollis* (12), as well as tetracolporate (11) and inaperturate (14) 60 to 100 μ in diameter, are dominant (Figs. 11 to 15)".

Campanian. - Gruppe 3, Pl. I, fig. 21 only, Aachen, Germany, KRUTZSCH (1957). Fulvelian. - *Appendicisporites tricuspidatus*, Saon, France Drome, IPERT (1976).

LM data the of the spores isolated from the brown coal amber bearing layers of Ajka

Amb triangular with convex sides (Plate 2.1., figs. 1,2). The laesurae of the tetrad mark reach the base of the appendices (Plate 2.1., figs. 1,2,4). Sculpture canaliculate, the size of four isolated striae and muri is about 20 μm (Plate 2.1., fig. 4). Diameter of the spore without appendices 48-60 μm, the appendices are 45-55 μm long so the size of the appendices is larger than the radius of the spore. Sometimes the appendices are bended in the direction of the proximal pole (Plate 2.1., figs. 1,2). It may be presumed that in the sporangia, the appendices were close to the spore body as is found in extant spore genus *Equisetum.* The appendices are characteristic twisted well shown in figs. 2,4 in Plate 2.1.

The new TEM results of the spores in the Ajkaite

A massula of laevigate spores of Schizaeaceae of "adriennis type" (Plate 2.1., fig. 5) occurred in our slides. TEM data from similar mass of spores was observed (Plate 2.1., fig. 7). The surface of the exospore is uneven and its inner part is, in general, electron dense. Similar mass of spores from the Paleozoic was published by WELLMAN, EDWARDS and AXE (1998), and WELLMAN (1999). Another spore, without protoplasm, occurred in our ultrathin sections of the amber (Plate, 2.1., fig. 6). The ultrastructure of the laesurae is also well shown with the inner part of the exospore being electron dense.

Discussion and Conclusions

The long appendices of *A. tricuspidatus* may be comparable to the elater bearing fossil and extant *Equisetum* spores. The fossil forms from the Pennsylvanian with three circinately coiled elaters were decribed by WILSON (1943) and assigned to *Elaterites triferens.* There are several papers concerning this subject with the most important ones, in our view, are as follows: POTONIÉ (1956) emphasized the following, p. 56: "Die Gattung zeigt Beziehung zu den mesozoischen Gattung *Appendicisporites* WEYLAND & KRIEGER 1953". GOOD and TAYLOR (1974) published LM and SEM photographs of *E. triferens* spores isolated from *Calamocarpon insignis* microsporangia. Fig. 6, in P. 149, illustrates a twisted elater with a striate surface. GOOD (1975) described several Calamitean cones with associated spores and a wind dissemination was emphasized for the function of the elater in *Equisetum.* "In the case of calamitalen spores it is also possible that elaters functioned as a means of propelling the spores from the sporangium and in doing so became detached" (GOOD, 1975, p. 84). The Mesozoic fossil elater bearing spore - *Equisetosporites* DAUGHERTY 1941 probably has four elaters following the

monograph of POTONIÉ (1956). KEDVES (1979) reviewed the most important basic results of the spores of the extant genus *Equisetum* through LM and SEM investigations of fourteen species. The striate surface of the elaters of these fourteen species was observed and the fine ornamentation was discussed. It is worth of mentioning that there are four elaters in the spores of *Equisetum* in contrast to those of the previously mentioned Paleozoic calamitean spores. After being subjected to high temperatures, the twisting of the elaters is more charactertistic. It can be presumed that the function of the Schizaeaceae appendices is similar to those of the Equisetaceae elaters. It also is noteworthy that the number of these appendices is three and different, in contrast, to the more or less globular Sphenopsida spores that are within the fossil forms of Schizaeaceae. This latter mentioned group, an isolated one of limited stratigraphical and geographical distribution, may have similar morphological features for their dispersion. This type of spore was discussed herein as an addition to the local elèments of the Upper Cretaceous flora of the Carpathian Basin. For example, the genus *Hungaropollis* GÓCZÁN 1964a has a similar restricted distribution. All these data are important for the understanding the fossil vegetation contained in the "amber tree".

The new data presented herein are important for the understanding the ultrastructure of fossil spores. It is hoped that, in spite of the fact that protoplasm was not preserved in the spores of this study, the information will be useful to future investigators. The superficial ultrastructure of the spore mass is comparable to the exospore of *Leiotriletes adriennis* (POTONIÉ et GELLETICH 1933) KRUTZSCH 1959 published first by KEDVES and PÁRDUTZ (1973).

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References

AMEROM, H.W.J. VAN (1965): Upper Cretaceous pollen and spores assemblages from the so-called "Wealden" of the province of Leon (Northern Spain). - Pollen et Spores *7*, 93-133.

BOLKHOVITINA, N.A. (1961): Fossil and present-day spores of the family Schizaeaceae. - Acad. Sci. U.R.S.S., Trud. Geol. Inst. *40*, 1-176.

DAUGHERTY, L.H. (1941): The Upper Triassic flora of Arizona. - Carniegie Inst. Wash., Pub. *526*, 1-108.

DAVIES, E.H. (1985): The Anemiacean, Schizaeacean and Related Spores: An Index to Genera and Species. - Canad. Techn. Rept. of Hydrography and Ocean Sci. *67*, Darthmouth, Nova Scotia.

DEÁK, H.M. (1963): Quelques spores striées de l'étage Aptien. - Revue de Micropaléontologie *5*, 251-236.

DEÁK, H.M. (1965): A Dunántuli Középhegység apti üledékeinek palynológiai vizsgálata. Recherches palynologiques des dépôts Aptiens de la Montagne Centrale de Transdanubie. - Geologica Hungarica ser. Palaeontologica *29-32*, 7-105.

DEÁK, M.H. et COMBAZ, A. (1967): «Microfossiles organiques» du Wealdien et du Cénomanien dans un sondage de Charente-Maritime. - Revue de Micropaléontologie *10*, 69-96.

DUCREUX, J.L., GAILLARD, M.G. et SAMUEL, E. (1982): Un gisement à plantes du Turonien supérieur la carrière de Sabran, à l'ouest de Bagnols sur-Cèze (Gard France) stratigraphie, sédimentologie, étude de macrorestes végétaux et palynologie. - Mém. Mus. Nat. d'Hist. Nat. N.S. C, Sciences de la Terre *49*, 71-79.

DURAND, S., TERS, F. et VERGER, F. (1963): Sur un nouveau gisement d'argile noire cénomanienne dans le marais de Monts (Vendée) et sa signification paléogéographique. - C.R. Acad. Sc. Paris *257*, 1492-1494.

GÓCZÁN, F. (1964a): Stratigraphic Palynology of the Hungarian Upper Cretaceous. - Acta Geologica *8*, 229-264.

GÓCZÁN, F. (1964b): A bakonyi szenon palynológiai standardje. Standard palynologique du Sénonien de la Montagne Bakony. - M.Á.F.I. évi jelentése az 1961. évről *1*, 253-261.

GOOD, C.W. (1975): Pennsylvanian-age Calamitean cones, elater-bearing spores, and associated vegetative organs. - Palaeontographica *B, 153*, 28-99.

GOOD, C.W. and TAYLOR, T.N. (1974): The establishment of *Elaterites triferens* spores in *Calamocarpon insignis* microsporangia. - Trans. Amer. Micros. Soc. *93*, 148-151.

GOOD, C.W. and TAYLOR, T.N. (1975): The morphology and systematic position of Calamitean elater-bearing spores. - Geoscience and Man *11*, 133-139.

GRANZOW, W. und HELMERICH, K.-D. (1992): *Plicatella appendicifera* (Sporomorphae) - eine taxonomische Betrachtung. - Senkenbergiana lethaea *71*, 439-445.

IPERT, C. (1976): Données palynostratigraphiques sur les formations des sables à lignites Dieulefit, Nyons et Saon (Drome). - Géobios *9*, 97-100.

KEDVES, M. (1979): Az *Equisetum* nemzetség recens spóráinak LM és SEM vizsgálata. Testing of the spores in the *Equisetum* genus. - Bot. Közlem. *66*, 195-203.

KEDVES, M. and ALVAREZ RAMIS, C. (2002): Types of sporomorphs from the Ajkaite containing brown coal samples from Ajka (Hungary). Tipos de esporomorfos determinados en mestras de lignito de las minas de Ajka (Hungría). - Plant Cell Biology and Development (Szeged) *14*, 7–10.

KEDVES, M., BORBOLA, A. and PRISKIN, K. (2001): LM and TEM investigations on the Upper Cretaceous Ajkaite of Hungary II. - Plant Cell Biology and Development (Szeged) *13*, 22-31.

KEDVES, M. et DINIZ, F. (1983): Les Normapolles du Crétacé supérieur en Europe: Implications Paléobiogéographiques. - Geobios *16*, 329-345.

KEDVES, M. and PÁRDUTZ, Á. (1973): Ultrastructure examination of fossil Pteridophyta spores and Gymnospermatophyta pollens. - Acta Bot. Acad. Sci. Hung. *18*, 307-313.

KEDVES, M., SZÓNOKY, M., MADARÁSZ, M. and KOVÁCS, G. (2000): LM and TEM investigations on the Upper Cretaceous Ajkaite, of Hungary I. - Plant Cell Biology and Development (Szeged) *12*, 9-17.

KEDVES, M., TÓTH, A. and FARKAS, E. (1991): High temperature effect on the spores of *Equisetum arvense* L. - Plant Cell Biology and Development (Szeged) *1*, 8-14.

KRUTZSCH, W. (1957): Sporen- und Pollengruppen aus der Oberkreide und dem Tertiär Mitteleuropas und ihre stratigraphische Verteilung. - Z. angew, Geol. *11/12* 509-548.

KRUTZSCH, W. (1959): Mikropaläontologische (sporenpaläontologische) Untersuchungen in der Braunkohle des Geiseltales. I. - Geologie BH. *21/22*, 1-425.

MÉDUS, J. et TRIAT, M. (1969): Le Cénomanien supérieur de la coupe de Laudun (Gard, France): Étude palynologique et données sédimentologiques. - Rev. Palaeobot., Palynol. *9*, 213-228.

PACLTOVÁ, B. and SVOBODOVÁ, M. (1992): Facial characteristics from the palynological point of view in the area of the Bohemian Cenomanian. - Paleofloristic and Paleoclimatic changes during Cretaceous and Tertiary. Geol ustav. Dionyza Stura, Bratislava, 17-24.

PANTIC, N.K. and DULIC, I.A. (1994): The study of reworked palynomorphs 1. Reworked palynomorphs in Alb-Cenomanian formation of Vojvodina and Belgrade Environs. - Ann. Geol. Penins. Balk. *58*, 101-117.

PANTIC, N.K. and DULIC, I.A. (1999): Some Contributions to the Stratigraphy of the Poganovo Paralic Series (Southeast Serbia). - Bull. T. CXIX de l'Académie serbe des sciences et des Arts, Classe des Sciences mathématiques et naturelles. Sciences naturelles N° *39*, 83-90.

POTONIÉ. R. (1956): Synopsis der Gattungen der Sporae dispersae I. Teil: Sporites. - Beih. Geol. Jb. *23*, 1-103.

POTONIÉ, R. und GELLETICH, J. (1933): Ueber Pteridophytensporen einer eozänen Braunkohle aus Dorog in Ungarn. - Sitz.-Ber. naturf. Fr. Berlin, 317-328.

SVOBODOVÁ, M. (1997): Mid-Cretaceous palynomorphs from the Blansko Graben (Czech Republic): affinities to both Tethyan and Boreal bioprovinces. - Proc. 4th EPPC Mid-Cretaceous palynomorphs from the Blansko Graben *58*, 149-156.

SVOBODOVÁ, M., MÉON, H. and PACLTOVÁ, B. (1998): Characteristics of palynospectra of the Upper Cenomanian-Lower Turonian (anoxic facies) of the Bohemian and Vocontian Basins. - Vestn-Ceského geol. ust. *73*, 229-252.

THIERGART, F. (1949): Der stratigraphische Wert mesozoischer Pollen und Sporen. - Palaeontographica *B, 89*, 1-34.

WELLMAN, C. H. (1999): Sporangia containing *Scylaspora* from the Lower Devonian of the Welsh Borderland. – Palaeontology *42*, 67–81.

WELLMAN, C.H., EDWARDS, D. and AXE, L. (1998): Ultrastructure of laevigate hilate spores in sporangia and spore masses from the Upper Silurian and Lower Devonian of the Welsh Borderland. - Phil. Trans. R. Soc. Lond. *B, 353*, 1983-2004.

WEYLAND, H. und GREIFELD, G. (1953): Über strukturbietende Blätter und pflanzliche Mikrofossilien aus den Untersenonen Tonen der Gegend von Quedlinburg. - Palaeontographica *B, 95*, 30-52.

WILSON, L.R. (1943): Elater-bearing spores from the Pennsylvanian strata of Iowa. - Amer. Midl. Nat. *30*, 518-523.